Ocean & Sea Ice SAF

Sea Ice

Product Manual

Version 3.8

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Documentation Change Record

Document version	Software version	Date	Change	Description
v 1.0				First version
v 2.3		01.11.2003		
v 2.4				
v 3.0	v 3.0	17.02.2005	Major	New product areas added, change in data format.
v 3.1	v 3.1	06.10.2005	Minor	Added information about how to read data formats.
v 3.2	v 3.1	19.10.2005	Minor	Added information about Sea Ice products disseminated through EUMETCast.
v 3.3	v 3.2	15.05.2006	Minor	Changed description of validation procedures, tiepoints and algorithms. New acknowledgements section. Timeliness is 6 hours, not 5. Minor text edits.
v 3.4	v 3.2	30.10.2006	Minor	Products on NetCDF format. Modified scatterometer descriptions. Text edits and rearranging.
V 3.5	V 3.2	23.01.2007	Minor	Added product info for EUMETCast SH products.
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The software version number gives the corresponding version of the OSI SAF High Latitude software chain for which the product manual is valid.

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1. Introduction

1.1 Overview

The Ocean & Sea Ice Satellite Application Facility (OSI SAF) is producing on an operational basis a range of air-sea interface products, namely: wind, sea ice characteristics, Sea Surface Temperatures (SST) and radiative fluxes, Surface Solar Irradiance (SSI) and Downward Longwave Irradiance (DLI).

This document is one of the product manuals dedicated to the OSI SAF product users. It describes the sea ice products.

Sea ice products are produced at the OSI SAF High Latitude processing facility (HL centre), operated jointly by the Norwegian and Danish Meteorological Institutes. Resulting sea ice fields are available daily within 6 hours after the last satellite data acquisition. This means within 06 UTC each day. The sea ice products are delivered with global coverage on two files, on for the Northern and on for the Southern Hemisphere. In addition a separate product for the Atlantic part of the northern Hemisphere is produced.

These three sea ice products are available with associated quality flags:

- Sea ice edge.
- Sea ice concentration; that is the fraction of the sea surface covered by ice.
- Sea ice type in terms of multiyear and firstyear ice.

The sea ice products have been developed to be derived from passive microwave, active microwave and optical sensors, using multi sensor methods with a Bayesian approach to combine different instruments and sensors. At present only SSM/I data from three channels is used operationally.

The basic development of the multi sensor ice edge and ice type products has been done using data from SSM/I and ERS-2 scatterometer. ERS-2 scatterometer data are to sparse and irregular and is therefore not used in the OSI SAF products. ASCAT scatterometer data from METOP was introduced in ice edge and ice type from 2009.

These products are delivered in GRIB, HDF5 and NetCDF format through the OSI SAF Sea Ice FTP server, EUMETSAT EUMETCast service and OSI SAF MERSEA sea ice portal (LDAP server). The products can also be made available through the Regional Meteorological Data Communication Network (RMDCN) to the European Meteorological services on request.

See [http://osisaf.met.no] for real time examples of the products and updated information. General information about the OSI SAF is given at [http://www.osi-saf.org].

Section 2 presents a brief description of the algorithms and section 3 gives an overview of the data processing. Section 4 provides detailed information on the file content and format, with more details in the Appendix A, B and C.

1.2 Glossary

AVHRR	Advanced Very High Resolution Radiometer
ASCAT	Advanced Scatterometer
BUFR	Binary Universal Form for the Representation of meteorological data
CMS	Centre de Météorologie Spatiale
DMI	Danish Meteorological Institute
DMSP	Defence Meteorological Satellite Programme
ECMWF	European Centre for Medium range Weather Forecast
ERS	European Remote Sensing Satellites
GRIB	GRIdded Binary form
GTS	Global Telecommunication System
HDF	Hierarchical Data format
HIRLAM	HIgh Resolution Limited Area Model
HL	High Latitudes
IOP	Initial Operational Phase
LML	Low and Mid Latitudes
met.no	Norwegian Meteorological Institute
NOAA	National Oceanic and Atmospheric Administration
NSIDC	National Snow and Ice Data Center
RMDCN	Regional Meteorological Data Communication Network
SAF	Satellite Application Facility
SSM/I	Special Sensor Microwave/Imager

1.3 Reference Documents

[RD.1] EPS End User Requirement Document (EUREUM.EPS.MIS.REQ.93.001)

2.   Algorithms

The developments of the OSI SAF sea ice algorithms have been presented in Breivik et al. (2001) and some aspects in more detail in Andersen (1998, 2000). The main principles of these developments are briefly presented here below.

2.1   Satellite data preprocessing

2.1.1   SSM/I preprocessing

Contamination arising from atmospheric water vapour content and wind roughening of the open water surface is a common problem in the remote sensing of sea ice from passive microwave observations. To mitigate this problem, a correction is computed using the radiative transfer model by Wentz (1997) extended with a scheme developed by S. Kern for the 85 GHz channels (Kern, 2004), with input from ECMWF and HIRLAM NWP model fields of surface wind, temperature and atmospheric water content. This correction is subsequently applied to the SSM/I brightness temperatures. Given a mixture of weather contamination and low ice concentrations, such as often experienced in the marginal ice zone, the widely used threshold based weather filtering methods such as described by Cavalieri et al. (1995) tend to either remove the ice completely or leave it untouched. The NWP model based correction method will tend to only remove the weather-induced part and give more accurate concentration estimates. Note that this method works directly on brightness temperatures and is therefore well suited for use in both the ice edge and type products as well as for the ice concentration product.

2.2   Bayesian multi sensor approach

A general tool for combining various data sources containing uncertain information is given by the Bayesian (inverse method) approach. Using this approach several measured parameters can be combined to yield an optimal estimate.

The approach is based on pre-knowledge of the averaged relationship between each *ice class* and the satellite-measured parameter. In addition knowledge of the scatter of the expected measurement value for each ice class is needed. This knowledge can be expressed as a probability density distribution for the measurement parameter *given the ice class*. As an example, allowing two classes: "ice" and "water", a simple algorithm for ice edge detection given a measured parameter A can be derived. We then need to estimate probability density distributions for the given "ice" and "water", *p(A|ice)* and *p(A|water)*. Setting both the prior probabilities for ice and water, P(ice) and P(water) equal to 50%, we get

$$p(ice|A) = \frac{p(A|ice)}{p(A|ice) + p(A|water)} \quad . \qquad (1)$$

The method can be generalised for combining several satellite-measured parameters to an optimal ice class estimate analysing several mutually independent classes. Assume that we have n measured parameters $A_1, A_2, \ldots, A_n$, which are independent given a certain ice class. A general expression can then be derived for the probability of an ice class I_k given the measured parameter:

$$P(I_k|A_1, \ldots, A_n) = \frac{p(A_1|I_k) \cdot p(A_2|I_k) \cdot \ldots \cdot p(A_n|I_k)}{\sum_j p(A_1|I_j) P(I_j) \cdot \ldots \cdot p(A_n|I_j) P(I_j)} P(I_k) \quad . \qquad (2)$$

The method works in such a way that the measured parameter, which the statistics shows to be most secure in distinguishing between ice classes, is the one that gives most impact in

the analysis. Further we do not only obtain an estimate of the most probable ice class, but also of the uncertainty of this estimate.

2.3   Ice class statistics

For the *ice edge* analysis three classes ($I_{1,2,3}$, Eq. 2) are defined: *open water*, *open ice* and *closed ice*. The limit between water and open drift ice is defined to be 35% ice concentration. The limit between open drift ice and close drift/very close drift ice is defined around 70 % ice concentration.

Ice type is divided in two classes*: first-year* (FY) and *multi-year* (MY) sea ice, where multi-year means ice that have survived at least one summer season.

The first step in building the analysis system based on the Bayesian approach is to derive the probability distributions for each ice class given the measured quantity. To obtain this statistical knowledge of the average, as well as of the scatter, of the expected measurement values, large sets of SSM/I and scatterometer observations have been collocated with background sea ice information. A set of target areas has been defined in the Arctic and the Antarctic. One year of SSM/I and ASCAT observations, March 2007 to February 2008, have been collocated with background sea ice information from the target areas. Each target area is representative for a certain ice class: closed ice, open ice open water, MY, FY and mixed ice. To differentiate between open and closed ice the operational OSI SAF ice concentration estimates are used as background information. To differentiate between MY and FY a sector north of Greenland and Canada between 30 W and 120 W are defined as MY while data from the Kara Sea, Baffin Bay, Laptev Sea and Bothnic Bay are defines as FY.

The sea ice properties influencing the measurements vary over the seasons. To account for seasonal variations, statistics are derived for each month.

2.4   Multi sensor Ice edge

2.4.1   SSM/I

From SSM/I data three parameters are used to distinguish between ice classes*.* These are:

- The polarisation ratio (normalised difference between horizontal and vertical brightness temperature) in the 19 GHz channel, *PR(19)*
- The polarisation ratio in the 85 GHz channel, *PR(85)*
- The gradient ratio, *GR(19,37)* (normalised difference in brightness temperature between 37 and 19 GHz)

The parameters are derived from the SSM/I brightness temperatures corrected for atmospheric influence as described in Section 2.5.1. Thus, collecting statistics as described above, the probability distributions $p(A_n|I_k)$ needed in Equation 2 are found.

2.4.2   ASCAT

The measured backscattering is relatively isotropic over sea ice compared to the strong anisotropic behaviour over open water, and the change of backscatter with incidence angle shows larger variation over water than over sea ice. Utilizing this properties a tie-point in the three dimensional sigma-0 (backscatter measurement) space are defined. The distance to this tie-point is called *anisFMB* and is used as the ASCAT ice edge parameter. For more details see the ASCAT algorithm development report, (Breivik and Eastwood, 2009). Thus, collecting statistics as described above the probability distributions $p(A_n|I_k)$ needed in Equation 2 are found.

2.4.3   Multi sensor

The OSI SAF ice edge product is using the three SSM/I parameters, *PR(19)*, *GR(19,37)* and *PR(85)* and the ASCAT parameter *anisFMB*. In the first step ice class (closed ice, open ice and water) -probabilities are estimated on the satellite swath projection for each passage. For SSM/I the low resolution data *PR(19)*, *GR(19,37)* are combined using Eq. 2. In the second step the ice class probabilities for each parameter is estimated on the OSI SAF 10 km grid using Eq. 2 on one day of data. The result is three probability estimates based on:

1) Combination of *PR(19)* and *GR(19,37)* from here called *SSM/I 1937*

2) Only *PR(85)* from here called *SSM/I 85*.

3) *anisFMB*

The resolution or footprint size of the *SSM/I 1937* measurements are approximately 25 km while for *SSM/I 85* it is approximately 12.5km. As the analysis is performed on a 10 km grid we would like to keep the higher resolution information provide by *SSM/I 85*. However, *SSM/I 85* is much more affected by atmospheric noise than the *SSM/I 1937*. The ASCAT input data is provided on a 12.5 km grid and by that comparable in resolution with *SSM/I 85*. However the ASCAT data are also noisy and the uncertainty expressed by the standard deviation of the distribution is clearly higher than for *SSM/I 1937*. A direct application of Eq 2 on the three parameters gives a smooth result dominated by SSM/I 1937 with few details in the ice edge.

To utilize more of the smaller scale information in *ASCAT* and *SSM/I 85* a new approach where *SSM/I 1937* is used as a filter is used. The final multi sensor analysis on the grid is done in two steps:

1) The final ice class probability on the grid is estimated using Eq. 2 and the *SSM/I 85* and *ASCAT* probabilities.

2) The *SSM/I 1937* results are then used as a filter where:

    a. A grid point where *p(water | SSMI/ 1937)* exceed 50 % is classified as water.

    b. A grid point where *p(closed ice | SSMI/ 1937)* exceed 50 % is classified as closed ice.

    c. A grid point without *SSM/I 1937* data is not processed but classified as "no data".

The result is a sharper ice edge with more details still with limited spurious ice due to atmospheric noise. More details and for examples are given in the ASCAT algorithm development report, (Breivik and Eastwood, 2009).

2.5   Multi sensor ice type

The multi-sensor method is also used to classify between two classes: first-year (FY) and multi-year (MY)sea ice.

Due to increased internal scattering in multi-year ice the change in radiation as a function of frequency can be used to distinguish between ice types (Steffen et. al. 1992). For SSM/I data the gradient ratio of the 19 and 37 GHz vertically polarized channels $GR(19,37,V)$ is therfore a good parameter to use in icetype classification.

For scatterometer the normalized backscatter from the sea ice surface is dependent on ice age. Multi-year ice is rougher than first-year and hence the backscatter is larger over multi-year ice. Multi-year ice, in particular during winter, will also have an additional backscatter signature compared to first-year ice as a result of volume scattering. Hence for ASCAT the measured backscatter is used for ice type classification.

More details and for examples are given in the ASCAT algorithm development report, (Breivik and Eastwood, 2009).

Using these two parameters the probabilities of ice type is calculated in a similar manner as for ice edge. 1) For each parameter successive estimation of ice type probability on the satellite swath data. 2) For each parameter (sensor) estimation of ice type probability on the OSI SAF grid based on one day data input. 3) Final multi sensor analysis on the OSI SAF grid. In the final step, the results from the ice edge analysis are used to classify open water.

In summer, when the first year ice gradually decreases or becomes multi year ice, the distinction between ice types becomes very difficult. This is partly due to melting resulting in wet ice and water on the ice. As a result, in the summer season basically from June to September there is no information on ice type in the data and the ice type is classified as "uncertain" in this period.

2.6   Estimation of sea ice concentration

Sea ice concentration is a continuous variable (0-100%) and not a class variable such as sea ice edge and sea ice type.

2.6.1   Monthly tiepoint set

With the channels featured by the SSM/I in combination with the radiative characteristics of sea ice, it is possible to account for 3 radiometrically distinct surfaces. This enables reasonably unambiguous estimates of arctic multiyear and firstyear ice concentrations during the winter season. In order to achieve this it is necessary to provide typical emissivities, commonly referred to as tie-points, of the pure type surfaces i.e. firstyear ice, multiyear ice and open water. Errors and inconsistencies in the estimated ice concentrations may arise when deviations from the tiepoint emissivities occur over time due to e.g. melting, snow cover effects and wind roughening of the ocean surface as well as spatially due to geographical differences in chemical and physical conditions. Nevertheless, tiepoint sets, supplied with the various sea ice concentration algorithms, are usually hemispheric and constant in time, although Comiso et al. (1997) has recently defined sets to cover the summer period for the Bootstrap algorithm. In addition existing tiepoint sets are often given in terms of observed brightness temperatures, which preclude the explicit correction for surface temperature variations. Finally, it is usual to define the water tiepoint based on minimum observed brightness temperatures, corresponding to a minimum atmospheric influence. However, due to the average atmospheric contribution, this results in an undesirable bias over open water and more frequent spurious ice concentrations.

A new global tiepoint set has been developed by Toudal (2006) using principal component analysis to determine clusters of sea ice and open water. This dataset has been introduced in version 3.2. It is global, more objective and based on a longer time series than the data set (Andersen, 1998) used previously. The monthly tiepoints allow to account for the mean annual cycle in sea ice emissivity.

2.6.2 SSM/I hybrid sea ice concentration algorithm

The analysis of atmospheric sensitivity in Andersen (2000) showed that the Bootstrap frequency mode algorithm (Comiso, 1986) had the lowest sensitivity to atmospheric noise over open water. Conversely, the comparison to high resolution SAR imagery in Andersen et al. (2006) revealed that of the algorithms using the low frequency channels (i.e. below 85 GHz), the Bristol algorithm gave the best agreement. Consequently a hybrid algorithm has been established as a smooth combination of two of the tested algorithms, the Bristol algorithm and the Bootstrap frequency mode algorithm. To ensure an optimum performance over both marginal and consolidated ice, and to retain the virtues of each algorithm, the Bristol algorithm is given little weight at low concentrations, while the opposite is the case over high ice concentrations.

2.6.3 Sea ice concentration analysis

A multi sensor analysis scheme for sea ice concentration analysis has been developed based on the Bayesian approach described in section 2.1. The analysis is a 2-step procedure. In the first step ice concentration is calculated in the swath projection for each satellite passage.

SSM/I ice concentration is calculated using the SSM/I hybrid sea ice concentration algorithm as described above for each observation node during the analysis interval (1 day). In the second step, the multi pass analysis, these results are analyzed on the 10 km OSI SAF grid. Several SSM/I observation nodes, with estimated concentrations, influence on each analysis grid point. The radius of influence, r, for each SSM/I observation is 18 km. The weight assigned to each SSM/I observation in the analysis is dependent on:

σ_n^2 : the variance of the SSM/I concentration estimate.
d : the distance between the centre of the SSM/I node and the grid point.

The variance of the SSM/I concentration estimates were found on basis of a large dataset of collocated SSM/I concentration estimates for passages close in time. Based on this dataset a model of the variance was defined as

$$\sigma_n = 0.04 + 0.07 \ (C_n \ (1-C_n)/0.25) \quad , \quad (4)$$

where σ_n is the standard deviation and C_n is the estimated ice concentration between 0.0 and 1.0. This model reflects the fact that the uncertainties are higher for intermediate concentrations than for very high or very low concentrations. Further σ_n is increased by a factor dependent on the distance d between the centre of the SSM/I node and the grid point.

Using this model for the variance of the SSM/I measurements and further assume Gaussian distributions around the concentration estimate C_n we can use the Bayesian approach as described in 2.1 to derive weights for the analysis. The most probable ice concentration C_A and its standard deviation σ_A in the SAF grid point is then found as a least square estimate:

$$C_A = \frac{\sum_{n=1}^{N} \sigma_n^{-2} C_n}{\sum_{n=1}^{N} \sigma_n^{-2}} \quad , \quad \sigma_A = \frac{1}{\sum_{n=1}^{N} \sigma_n^{-2}} \quad . \quad (5)$$

The sum is performed over all satellite passages $n = 1,...N$ influencing a grid point in the analysis grid. The output of this analysis is the actual SSM/I derived ice concentration C_A, and its standard deviation σ_A. σ_A is a measure of the uncertainty of the results and is used to construct weights for the multi sensor analysis.

In the next step the results from SSM/I and other sensors are used to perform the final analysis on the SAF grid. The input data to the multi sensor ice concentration analysis are the analyzed ice concentrations and its standard deviations on each SAF grid point from different sensors. The standard deviations are used to construct the weights, and the analysis are performed as given in Eq. 5 with $N=2$. The final σ_A is used to produce quality flags.

2.7 References

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3.   Processing scheme

3.1 Overview

The delivered products are daily means centered on noon. The sea ice products are derived from SSM/I data from the DMSP F15 satellites acquired by FTP at the OSI SAF High Latitude processing centre and from ASCAT data received via EUMETCast.

Section 3.2 describes the primary processing made on the individual satellite passes. The merging of the data from various origins is presented in section 3.3. To this basic processing is added the validation and quality control described in section 3.4.

3.2 Primary processing

3.2.1 Satellite data

SSM/I
SSM/I pass data are fetched in BUFR format from UK Met Office by the OSI SAF High Latitude processing centre. Each pass is subsetted to cover both the Northern and Southern hemisphere. Atmospheric corrections, based on ECMWF NWP model output, are then applied to the brightness temperatures. The data is reformatted and stored in NetCDF.

ASCAT
ASCAT pass data are received in BUFR format on EUMESTCast by the OSI SAF High Latitude processing centre. Each pass is subsetted to cover both the Northern and Southern hemisphere. The data is reformatted and stored in NetCDF.

3.2.2 Ancillary data

Ancillary data are given on the OSI SAF grid and used to mask away land and coast and erroneous ice. The uses of the ancillary data are marked as a flag for each grid point in the data quality file (see section 4.3).

Land-sea-coast: contains land, coast and sea occurrences. It has been derived on the OSI SAF grids from the World Vector Shoreline. In the Southern Hemisphere, information on ice shelf coverage has been added from the NASA AMSR-E landmasks and a mask based on inspection of recent VIS-IR imagery developed by S. Kern, University of Hamburg. The atlas includes 3 types of pixels: "land", "coast" and "sea". Sea ice calculations are done over the "sea" pixels. The "coast" pixels are pixels within a fixed distance from the coastline over sea areas. This fixed distance is chosen in accordance with the size of the footprint of the SSM/I data. Observations within these pixels are not processed since they are most likely contaminated by land. These pixels are given the value "unclassified" in the data products.

Sea ice climatology: contains monthly fields of maximum sea ice extent (Ocean Masks) provided by NSIDC (see [http://nsidc.org] for details). This dataset is based on data from SMMR and SSM/I spanning the period from 1979 through 2002.

Background data: To make the product more useful for automatic use, obviously erroneous classified sea ice is removed by use of background information derived from the NWP model. The parameter chosen for this purpose is the NWP temperature analysis field at 2m (T2m). A spurious ice filtering is implemented by setting all grid points with T2m>8.0°C to open water. Experience shows that the value, T2m>8.0°C, is high enough to account for uncertainty in the NWP analysis and ensure proper distance from the ice edge. The value is however

tunable and given as an input parameter. To avoid the erroneous removal of extreme ice extents, the NSIDC climatological maximum sea ice edge is expanded towards open water by 50 km before being added to the NWP background data. Finally, the ice edge (delineated by the 15 % ice concentration contour) from the day before is expanded towards open water by 100 km and added.

Ice type mask: To reduce noise in the ice type products an ice type mask is defined. Areas where multi-year ice never occur, e.g. the Bothnic Bay is masked as first-year the mask is used to overrule the erroneous classification and ensure FY.

3.3 Daily calculations

As described in section 2 the first step of the analysis is performed successively as the data arrive. In this the step the probabilities for ice classes (closed ice, open ice, open water, first-year ice and multi-year ice) and ice concentration (only SSM/I) are calculated on each observation point in satellite projection.

In the next step, daily calculations are then performed each day at *0400* UTC and are based on data collected from the previous day. The offset of four hours is used because the SSM/I data are delayed by up to 4 hours.

3.4 Validation and quality control

Validation and assessments of product performance information is published on a monthly basis and is based on both objective and subjective comparisons with high quality navigational sea ice analyses produced at the operational Sea Ice Services at DMI and met.no. These navigation ice charts have requirements very different from the OSI SAF products one. They are therefore to a large extent based on subjective interpretation of high resolution SAR and AVHRR data. However, in areas where SAR or AVHRR data is not available for subjective analysis the sea ice analysts will use SSM/I data and OSI SAF products. The sea ice analysts at DMI and met.no are aware of this potential problem when validating the OSI SAF sea ice products. **Therefore only navigation ice charts based on subjective interpretation of high resolution SAR, MODIS and AVHRR data are used in the evaluation of the OSI SAF products.**

3.4.1 Objective evaluation

For the objective comparisons the following parameters have been defined:

Product	Quality parameter	Definition
Ice edge	Area of discrepancy	Where the navigational ice edge is classified as certain, the number of HL grid pixels is counted where the SAF classification does not match the navigational classification.
Concentration	Concentration within bounds	Where the navigational ice concentration is classified as certain, the number of cases where the concentration of the SAF product falls within the interval given in the navigational analysis is counted. This count should be normalised by the total number of collocated pixels.

Table 1: Criterias for comparing ice charts with OSI SAF sea ice products.

The evaluation procedure is currently running operationally at DMI for the Greenland area and at met.no for the Svalbard area.

At DMI the products are compared once a week statistically with the weekly DMI ice navigational analysis for the entire Greenland area. These ice analyses compile all available satellite data, including Radarsat SAR, NASA MODIS and NOAA AVHRR for a weekly reference date at 12 UTC (± 24 hours). No additional ice products are believed to have a better accuracy compared with coverage. An example of the he weekly ice analysis for operational use is available at

http://www.dmi.dk/dmi/index/gronland/iskort.htm.

At met.no the products are compared with the daily (weekdays) ice charts to produce similar statistics as described for DMI. The trained ice analysts use as input Radarsat SAR, ENVISAT GlobalMode and WideSwath SAR, MODIS and NOAA AVHRR. The products are compared only in areas selected by the ice analysts, where detailed satellite data are available that has not been used on the OSI SAF product. The daily ice analysis for operational use from met.no is available at

http://met.no/kyst_og_hav/iskart.html.

3.4.2 *Subjective evaluation/error registration*

All OSISAF sea ice products are evaluated by skilled ice analysts on a daily basis. A predefined set of error types are used as a reference for registering non-nominal cases of false ice or missing ice. This registration is used complementary to the objective evaluation. Although the objective evaluation provides a quality assessment it does not detect possible non-nominal cases of ice/no-ice presence. The manual error registration on the other hand, collects on a daily basis the possible errors caused by anomalous situations with data or processing. In Appendix E a description of each error and noise feature is provided.

4.   Data description

4.1   Overview

For each of the three daily sea ice products, data users will have access to the following categories of data:

- a sea ice parameter
- a quality index field

These products are available on GRIB, HDF5 and NetCDF3 format. For GRIB and HDF5 the sea ice parameter and quality index are on separate files, while for NetCDF they are on the same file.

The results of the validation and quality control in the form of updated tables and written quality reports are available at the OSI SAF Sea Ice web portal [http://osisaf.met.no], under "Validation" and "Documents.

This section includes the definition of the fields (sections 4.2 and 4.3) and a description of the formats used (section 4.4). Additional information can be found in Appendices A, B and C.

4.2   Sea ice products

4.2.1   Common characteristics

Physical definition

Sea ice edge: Indicates whether a given grid point is ice free or not.

Sea ice concentration: Indicates the areal fraction in percentage of a given grid point covered by ice.

Sea ice type: Indicates the dominant ice type in terms of first year or multi year ice. Multi year ice has by definition survived one yearly cycle of freeze and melt, first year ice has been formed during the past year.

Units and range

Sea ice edge is given as an integer code, with the following significance:
- 0: No data
- 1: Ice free
- 2: Open ice (35 -70% concentration)
- 3: Closed ice (70-100% concentration)
- 9: Over land
- 10: Unclassified.

Sea ice concentration is given as a real number:
- 0 -100.0: Area fraction of ice in percentage
- -99.0: Over land
- -199.0: Unclassified
- -32767.0: No data.

Sea ice type is given as an integer code, with the following significance:
- 0: No data
- 1: Ice free
- 2: First year ice
- 3: Multi year ice
- 4: Ambiguous
- 9: Over land
- 10: Unclassified.

4.2.2 Grid characteristics

The product grids are adapted from the 25 km resolution Goddard Space Flight Center projections used to disseminate various SSM/I based products available at the National Snow and Ice Data Center (see [http://nsidc.org] for details). There is one grid for the Northern Hemisphere product (NH) and one grid for the Southern Hemisphere product (SH), as seen in Figure 1.

Below are given the details of the grid definitions and approximate maps of the grid extents, corner coordinates are referenced to pixel center. Projection definitions in the form of PROJ-4 initialization strings are also given (see [http://trac.osgeo.org/proj/] for details).

Geographical definition for Northern Hemisphere Grid, NH	
Projection:	Polar stereographic projection true at 70°N
Resolution:	10 km
Size:	760 columns, 1120 lines
Central Meridian:	45°W
Lower left grid point:	33.9755°N, 80.7299°W
Radius of Earth:	6378273 x 6356889.44891 m
PROJ-4 string:	+proj=stere +a=6378273 +b=6356889.44891 +lat_0=90 +lat_ts=70 +lon_0=45
Geographical definition for Southern Hemisphere Grid, SH	
Projection:	Polar stereographic projection true at 70°S
Resolution:	10 km
Size:	790 columns, 830 lines
Central Meridian:	0°
Lower left grid point:	41.5015°S, 135.0000°W
Radius of Earth:	6378273 x 6356889.44891 m
PROJ-4 string:	+proj=stere +a=6378273 +b=6356889.44891 +lat_0=-90 +lat_ts=-70 +lon_0=0

Table 2: Definition of NH and SH grids.
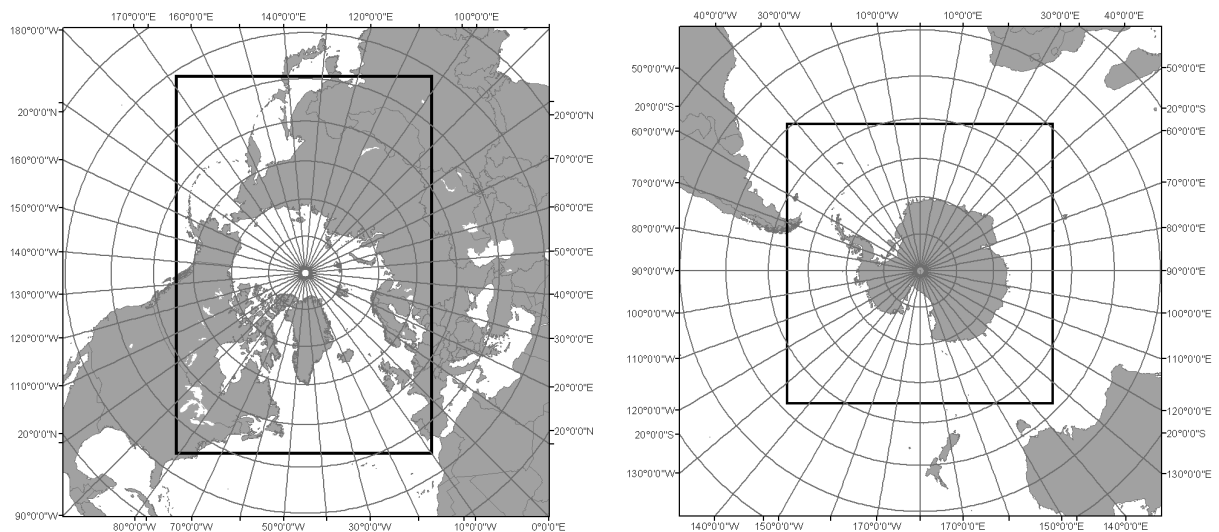
Figure 1: Coverage of the Northern (left) and Southern (right) Hemisphere grids, marked with the black box (from NSIDC).

4.3 Associated field, Quality indexes

Each sea ice field is associated with a quality index field, coded in 16-bit words. This index includes a confidence level corresponding to the quality of the calculated sea ice parameter and information on the processing conditions, which may have some interest to the user, the OSI SAF team or both.

4.3.1 Sea Ice Edge quality index

The quality index of the Sea Ice Edge consists of the following quality flags:

Bits	Name	Description
0-2	Confidence level	5 = Excellent, 4 = Good, 3 = Acceptable, 2 = Unreliable, 1 = Erroneous, 0 = Unprocessed
3	SSM/I concentration used	True if SSM/I concentration estimate is used
4	SSM/I 85 GHz used	True if SSM/I 85 GHz data is used
5-6	Number of SSMI orbits used (only valid if bit 3 or 4 are true)	0: 1 1: 2-5 2: 6-10 3: 11+
7	Scatterometer used	True if scatterometer data is used
8-9	Number of Scatterometer orbits used (only valid if bit 7 is true)	0: 1 1: 2-5 2: 6-10 3: 11+
10	AVHRR used	True if AVHRR data is used
11-12	Number of AVHRR orbits used (only valid if bit 10 is true)	0: 1 1: 2-5 2: 6-10 3: 11+
13	Background data	True if background data is used
14	Spare	
15	No ice data	0 = false, 1 = true

Table 3: Description of sea ice edge quality index.

The 3-bit confidence level is defined using the calculated probabilities of the present sea ice edge class. The confidence levels are defined as follows:

Excellent: 99-100% probability
Good: 95-98% probability
Acceptable: 75-94% probability
Unreliable: 50-74% probability
Erroneous: Computation failed
Unprocessed: No data

4.3.2 Sea Ice Type quality index

The quality index of the Sea Ice Type consists of the following quality flags:

Bits	Name	Description
0-2	Confidence level	5 = Excellent, 4 = Good, 3 = Acceptable 2 = Unreliable, 1 = Erroneous, 0 = Unprocessed
3	SSM/I used	True if SSM/I Gradient ratio is used
4-5	Number of SSM/I orbits used (only valid if bit 3 is true)	0: 1 1: 2-5 2: 6-10 3: 11+
6	Scatterometer used	True if scatterometer data is used
7-8	Number of Scatterometer orbits used (only valid if bit 6 is true)	0: 1 1: 2-5 2: 6-10 3: 11+
9	Background data	True if background data is used
10	Ice type mask	True if static ice type mask used
11-14	Spare	
15	No ice data	0 = false, 1 = true

Table 4: Description of sea ice type quality index.

The 3-bit confidence level is defined using the calculated probabilities of the present sea ice type class. The confidence levels are defined as follows:

Excellent: 99-100% probability
Good: 95-98% probability
Acceptable: 75-94% probability
Unreliable: 50-74% probability
Erroneous: Computation failed
Unprocessed: No data

4.3.3   Sea Ice Concentration quality index

The quality index of the Sea Ice Concentration consists of the following quality flags:

Bits	Name	Description
0-2	Confidence level	5 = Excellent, 4 = Good, 3 = Acceptable 2 = Unreliable, 1 = Erroneous, 0 = Unprocessed
3	SSMI used	True if SSMI data used
4-5	Number of SSMI orbits used (only valid if bit 3 is true)	0: 1 1: 2-5 2: 6-10 3: 11+
6	AVHRR used	True if AVHRR data used
7-8	Number of AVHRR orbits used (only valid if bit 6 is true)	0: 1 1: 2-5 2: 6-10 3: 11+
9	Background data	0: False 1: True
10-14	Spare	
15	No ice data	0 = false, 1 = true

Table 5: Description of sea ice concentration quality index.

The 3-bit confidence level is defined using the calculated standard deviation of the present sea ice concentration. The confidence levels are defined as follows:

Excellent: 0 - 1.5
Good: 1.5 – 2.5
Acceptable: 2.5 – 3.5
Unreliable: 3.5 – 10.
Erroneous: 10. ->
Unprocessed: No data

4.3.4 Status flag on NetCDF files

The NetCDF3 files contains a status flag variable instead of the quality index variable, in addition to a variable with the confidence level. The content of this status flag is described in Table 6.

Value	Description
0	Nominal value from algorithm used
2	Sea ice algorithm applied over lake
10	Background data was used for setting the value
14	Value set using an ice type mask (only ice type product)
100	Missing value due to over land
101	Missing value due to missing data
102	Unclassified pixel

Table 6: Description of status flag values.

4.4 File formats

The products are available under WMO GRIB format, NCSA HDF5 format and Unidata NetCDF format. A complete description of the GRIB format can be found in WMO publication No 306, Manual on Codes. A few parameters are encoded in the GRIB header. This manual is available at:

http://www.wmo.ch/web/www/WMOCodes/ManualCodes/WMO306vol-I-2PartB.pdf.

The header sections of the GRIB files contain the metadata for the OSI SAF products, and these are described in the appendix A. Due to limitations in the GRIB format, there are fewer metatdata in the GRIB files than in the HDF5 and NetCDF files. A tool for reading GRIB files can be found at ECMWF under:

http://www.ecmwf.int/products/data/software/download/gribex.html.

The HDF5 format is a public format. Documentation is found at

http://www.hdfgroup.org/HDF5/doc

The metadata are stored in HDF5 attributes. Appendix B describes the HDF5 attributes defined for the sea ice data products.

The NetCDF3 format is a public format, with documentation available at:

http://www.unidata.ucar.edu/software/netcdf

The OSI SAF sea ice products use the CF 1.4 standard for metadata in the NetCDF files. The metadata in the NetCDF files are described in Appendix C. More metadata have been added to the NetCDF files compared to the HDF5 files.

More information about the OSI SAF sea ice data formats can be found at [http://osisaf.met.no] under Data formats.

4.5 Data distribution

There are two main sources for collecting the OSI SAF Sea Ice products; by FTP or through EUMETCast. In addition the products can be delivered through the Regional Meteorological Data Communication Network (RMDCN) on request.

At the OSI SAF Sea Ice FTP server [ftp://osisaf.met.no/prod/ice] the products are available on GRIB and NetCDF3 and HDF5 format. Here products from the last month can be collected. In addition there is a separate directory with archive of all previously produced sea ice products (up to the last available product) at [ftp://osisaf.met.no/archive/ice]. The file name convention for these products is given in the table below.

Through the EUMETSAT EUMETCast service the OSI SAF Sea Ice products are available on the GRIB format. The distributed files have been compressed with `gzip`. Different file name conventions have been chosen for the Sea Ice products at EUMETCast since many different products are disseminated through EUMETCast. More information about the EUMETCast service can be found at [http://www.eumetsat.int].

The following two tables give the file name convention used at the OSI SAF FTP server.

Sea Ice GRIB and HDF5 files	
Product	**File name**
Ice concentration	ice_conc_<area>_<date12>.<format>
Ice concentration quality index	ice_conc_<area>_qual_<date12>.<format>
Ice edge	ice_edge_<area>_<date12>.<format>
Ice edge quality index	ice_edge_<area>_qual_<date12>.<format>
Ice type	ice_type_<area>_<date12>.<format>
Ice type quality index	ice_type_<area>_qual_<date12>.<format>
Sea Ice NetCDF3 files	
Ice concentration	ice_conc_<area>_polstere-100_multi_<date12>.nc
Ice edge	ice_edge_<area>_polstere-100_multi_<date12>.nc
Ice type	ice_type_<area>_polstere-100_multi_<date12>.nc

Table 7: File name convention for the sea ice files on the OSI SAF FTP server.

<area>: NH for Northern Hemisphere products, SH for Southern Hemisphere.
<date12>: Date and time of the product on format YYYYMMDDHOMI, e.g. 200701221200.
<format>: file format, grb=GRIB, hdf=HDF5, nc=NetCDF3.

The following two tables give the file name convention used for the products disseminated through EUMETCast.

Product	File name
Sea Ice Concentration	S-OSI_-NOR_-MULT-GL_<area>_CONC__-<date12>.grb.gz
Sea Ice Concentration quality index	S-OSI_-NOR_-MULT-GL_<area>_CONC_Q-<date12>.grb.gz
Sea Ice Edge	S-OSI_-NOR_-MULT-GL_<area>_EDGE__-<date12>.grb.gz
Sea Ice Edge quality index	S-OSI_-NOR_-MULT-GL_<area>_EDGE_Q-<date12>.grb.gz
Sea Ice Type	S-OSI_-NOR_-MULT-GL_<area>_TYPE__-<date12>.grb.gz
Sea Ice Type quality index	S-OSI_-NOR_-MULT-GL_<area>_TYPE_Q-<date12>.grb.gz

Table 8: File name convention for the sea ice files on EUMETCast.

APPENDIX A: Limited description of the GRIB file header

The GRIB files are written using the EMOS library, developed at ECMWF. Internally, the data are stored using the GRIB bitmap convention, which means that missing value elements are marked and removed. The user should be aware that on retrieval, these elements will be assigned a user defined value that should be set to the missing value for the given field. This is e.g. 0 for ice edge data and -32767.0 for ice concentration data.

The parameters in sections 1, 2 and 3 of the GRIB files, which are specific to the OSI SAF Sea Ice products, are given in the following table. The parameter names or values with an asterisk (*) refer to tables given in WMO publication No 306 - Manual on Codes. Note that the earth figure used cannot be adequately coded following the GRIB standard. The earth figure implied in the component flags bitmask of section 2 octet 17 is not meaningful. For convenience the two earth radii and latitude of true scale have been stored as vertical components in section 2. Due to the floating point representation used in GRIB the earth radii are accurate only to the nearest meter; however this has no practical significance. This deviation from the standard has been marked by double asterisks (**).

Octet	Content	Value
Section 1		
1-3	Length in octets of Section 1	
4	Version number	3
5	Center identifier	88 for met.no Oslo
6	Process identifier	1 for met.no Oslo
7	grid definition	255 (grid defined in Section 2)
8	flag section 2 and 3	128* for the quality index fields (TBC)
		192* for the other fields (TBC)
9	Parameter	220 for sea ice edge
		231 for sea ice edge quality index
		221 for sea ice type
		232 for sea ice type quality index
		91* for sea ice concentration
		230 for sea ice concentration quality index
10	type of level	1*
11-12	Level	0*
13-17 and 25	Reference time	
18	time unit indicator	2*
19	P1*	0
20	P2*	0
21	time range indicator	0
22-23	Number of products included	number of hourly fields (or orbits) actually included in the product
24	Number of products missing	number of missing hourly fields (or orbits)
27-28	Decimal scale factor	0*
29	Local use flag	0* (no local use)
Section 2		
1-3	Length in octets of Section 2	
4	Number of vertical coordinate parameters	3**
5	Location of the list of vertical coordinate parameters	255* (not present)
6	data representation type	5 (Polar stereographic projection grid)
7-8	Number of points along x-axis	760 for NH, 790 for SH, 630 for HL
9-10	Number of points along y-axis	1120 for NH, 830 for SH, 450 for HL
11-13	Latitude of first grid point	33975 for NH, -41502 for SH, 37399 for HL
14-16	Longitude of first grid point	-80730 for NH, -135000 for SH, -40168 for HL
17	Resolution and component flags	00000000*
18-20	Longitude of the meridian parallel to y-axis	-45000 for NH, 0 for SH, 0 for HL
21-23	x-direction grid length	10000
24-26	y-direction grid length	10000
27	Projection centre flag	0* (North pole on the projection plane) for NH/HL
		128* (South pole on the projection plane) for SH
28	Scanning mode flags	01000000*
33-36	Major axis	6378273** for NH and SH, 6371000** for HL
37-40	Minor axis	6356890** for NH and SH, 6371000** for HL
41-44	Latitude of true scale	70.0 for NH**, -70.0 for SH**, 60.0 for HL

Section 3		
1-3	Length in octets of Section 3	
4	Number of unused bits at the end of Section 3	
5-6	Bitmap flag	1* for the quality index field 0* for the other fields

Table 9: Limited description of OSI SAF Sea Ice GRIB data files header.

APPENDIX B: The OSIHDF5 format

The sea ice products are stored in a local implementation of the HDF5 format, which is called the OSIHDF5 format. More details about this format is presented in a separate document, "Description of the osihdf5 format" (Godøy, 2005), available at the OSI SAF Sea Ice web portal [http://osisaf.met.no], under Documents. The information presented here describes all the metadata in the product files.

The tables in this appendix give the description of the parameters and the content of the fixed parameters for each sea ice product.

Object	Element	Contents
Header	source	Source of product, "OSI_SAF_HL" for all products.
	product	Type of product.
	area	Name of product grid area.
	projstr	PROJ-4 string for product projection.
	iw	Image width.
	ih	Image height.
	z	Number of fields in file, "1" for all products.
	Ax	Pixel size in x and y-direction.
	Ay	
	Bx	x and y-position of upper left corner of upper left pixel in UCS coordinates.
	By	
	year	Date and time of product.
	month	
	day	
	hour	
	minute	
data[00]	description	Description of data field.
	osi_dtype	Data value type.

Table 10: Description of OSI SAF Sea Ice products HDF5 file format.

Parameter	NH grid	SH grid
area	"OSISAF_NH"	"OSISAF_SH"
projstr	(see tables in section 4.2.2 for values)	
iw	760	790
ih	1120	830
Ax	10.0	10.0
Ay	10.0	10.0
Bx	-3850.0	-3950.0
By	5850.0	4350.0

Table 11: Values for OSI SAF Sea Ice HDF5 files fixed header parameters.

Sea Ice Product	Header/"product"	data/"description"	data/"osi_dtype"
Ice concentration	"Ice Conc"	"Ice Conc"	OSI_FLOAT
Ice concentration quality index	"Ice Conc QF"	"Ice Conc QF"	OSI_UINT
Ice edge	"Ice Edge"	"Ice Edge"	OSI_UCHAR
Ice edge quality index	"Ice Edge QF"	"Ice Edge QF"	OSI_UINT
Ice type	"Ice Type"	"Ice Type"	OSI_UCHAR
Ice type quality index	"Ice Type QF"	"Ice Type QF"	OSI_UINT

Table 12: Values for OSI SAF Sea Ice HDF5 files fixed parameters.

Appendix C: Sea Ice products on NetCDF format

Below is given an example of the NetCDF header of a sea ice concentration file. The header parameters are similar for sea ice edge and sea ice type.

```
netcdf ice_conc_nh_polstere-100_multi_201205101200 {
dimensions:
  time = 1 ;
  nv = 2 ;
  xc = 760 ;
  yc = 1120 ;
variables:
  int Polar_Stereographic_Grid ;
      Polar_Stereographic_Grid:grid_mapping_name="polar_stereographic" ;
      Polar_Stereographic_Grid:straight_vertical_longitude_from_pole = -45.f ;
      Polar_Stereographic_Grid:latitude_of_projection_origin = 90.f ;
      Polar_Stereographic_Grid:standard_parallel = 70.f ;
      Polar_Stereographic_Grid:false_easting = 0.f ;
      Polar_Stereographic_Grid:false_northing = 0.f ;
      Polar_Stereographic_Grid:semi_major_axis = 6378273.f ;
      Polar_Stereographic_Grid:semi_minor_axis = 6356890.f ;
      Polar_Stereographic_Grid:proj4_string = "+proj=stere +a=6378273 ",
          "+b=6356889.44891 +lat_0=90 +lat_ts=70 +lon_0=-45" ;
  double time(time) ;
      time:axis = "T" ;
      time:long_name = "reference time of product" ;
      time:standard_name = "time" ;
      time:units = "seconds since 1978-01-01 00:00:00" ;
      time:calendar = "standard" ;
      time:bounds = "time_bnds" ;
  double time_bnds(time, nv) ;
      time_bnds:units = "seconds since 1978-01-01 00:00:00" ;
  double xc(xc) ;
      xc:axis = "X" ;
      xc:units = "km" ;
      xc:long_name = "x coordinate of projection (eastings)" ;
      xc:standard_name = "projection_x_coordinate" ;
  double yc(yc) ;
      yc:axis = "Y" ;
      yc:units = "km" ;
      yc:long_name = "y coordinate of projection (northings)" ;
      yc:standard_name = "projection_y_coordinate" ;
  float lat(yc, xc) ;
      lat:long_name = "latitude coordinate" ;
      lat:standard_name = "latitude" ;
      lat:units = "degrees_north" ;
  float lon(yc, xc) ;
      lon:long_name = "longitude coordinate" ;
      lon:standard_name = "longitude" ;
      lon:units = "degrees_east" ;
  short ice_conc(time, yc, xc) ;
      ice_conc:long_name = "concentration of sea ice" ;
      ice_conc:standard_name = "sea_ice_area_fraction" ;
      ice_conc:units = "%" ;
      ice_conc:_FillValue = -999s ;
      ice_conc:valid_min = 0s ;
      ice_conc:valid_max = 10000s ;
      ice_conc:grid_mapping = "Polar_Stereographic_Grid" ;
      ice_conc:coordinates = "lat lon" ;
      ice_conc:scale_factor = 0.01f ;
      ice_conc:add_offset = 0.f ;
  byte confidence_level(time, yc, xc) ;
      confidence_level:long_name = "confidence level" ;
      confidence_level:valid_min = 0b ;
      confidence_level:valid_max = 5b ;
      confidence_level:grid_mapping = "Polar_Stereographic_Grid" ;
```

```
        confidence_level:coordinates = "lat lon" ;
        confidence_level:flag_values = 0b, 1b, 2b, 3b, 4b, 5b ;
        confidence_level:flag_meanings   =   "unprocessed   erroneous   unreliable
acceptable good excellent" ;
        confidence_level:flag_descriptions = "\n",
             "  0 -> not processed, no input data\n",
             "  1 -> computation failed\n",
             "  2 -> processed but to be used with care\n",
             "  3 -> nominal processing, acceptable quality\n",
             "  4 -> nominal processing, good quality\n",
             "  5 -> nominal processing, excellent quality" ;
   byte status_flag(time, yc, xc) ;
        status_flag:long_name  =  "status  flag  for  concentration  of  sea  ice
retrieval" ;
        status_flag:standard_name = "sea_ice_area_fraction status_flag" ;
        status_flag:_FillValue = -1b ;
        status_flag:valid_min = 0b ;
        status_flag:valid_max = 102b ;
        status_flag:grid_mapping = "Polar_Stereographic_Grid" ;
        status_flag:coordinates = "lat lon" ;
        status_flag:flag_values = 0b, 2b, 10b, 14b, 100b, 101b, 102b ;
        status_flag:flag_meanings  =  "nominal  lake  background  type_mask  land
missing unclassified" ;
        status_flag:flag_descriptions = "\n",
             "  0 -> nominal value from algorithm used\n",
             "  2 -> sea ice algorithm applied over lake\n",
             " 10 -> background data was used for setting the value\n",
             " 14 -> value set using an ice type mask\n",
             "100 -> missing value due to over land\n",
             "101 -> missing value due to missing data\n",
             "102 -> unclassified pixel" ;

// global attributes:
        :title = "Daily Sea Ice Concentration Analysis from OSI SAF EUMETSAT" ;
        :product_id = "OSI-401" ;
        :product_name = "osi_saf_ice_conc" ;
        :product_status = "operational" ;
        :abstract = "The daily analysis of sea ice concentration is obtained",
             "from operation satellite images of the polar regions. It is",
             "based on atmospherically corrected signal and a carefully",
             "selected sea ice concentration  algorithm.  This  product  is",
             "freely available from the EUMETSAT  Ocean  and  Sea  Ice",
             "Satellite Application Facility (OSI SAF)." ;
        :topiccategory = "Oceans ClimatologyMeteorologyAtmosphere" ;
        :keywords = "Sea Ice Concentration, Sea Ice, Oceanography,",
                  "Meteorology, Climate, Remote Sensing" ;
        :gcmd_keywords = "Cryosphere > Sea Ice > Sea Ice Concentration\n",
             "Oceans > Sea Ice > Sea Ice Concentration\n",
             "Geographic Region > Northern Hemisphere\n",
             "Vertical Location > Sea Surface\n",
             "EUMETSAT/OSISAF > Satellite Application Facility on Ocean and",
             "Sea Ice, European Organisation for the Exploitation of",
             "Meteorological Satellites" ;
        :northernmost_latitude = 90.f ;
        :southernmost_latitude = 30.98056f ;
        :easternmost_longitude = 180.f ;
        :westernmost_longitude = -180.f ;
        :activity_type = "Space borne instrument" ;
        :area = "Northern Hemisphere" ;
        :instrument_type = "Multi-sensor analysis" ;
        :platform_name = "Multi-sensor analysis" ;
        :start_date = "2012-05-10 00:00:00" ;
        :stop_date = "2012-05-11 00:00:00" ;
        :project_name = "EUMETSAT OSI SAF" ;
        :institution = "EUMETSAT OSI SAF" ;
        :PI_name = "Rasmus Tonboe" ;
        :contact = "osisaf-manager@met.no" ;
        :distribution_statement = "Free" ;
```

```
        :copyright_statement = "Copyright 2012 EUMETSAT" ;
        :references = "OSI SAF Sea Ice Product Manual, Eastwood S. (editor),",
                  "v3.8, May 2012\n",
                  "http://osisaf.met.no\n",
                  "http://www.osi-saf.org" ;
        :history = "2012-05-11 creation" ;
        :product_version = "2.2" ;
        :software_version = "4.1" ;
        :netcdf_version = "3.6.3" ;
        :Conventions = "CF-1.4" ;
```

Appendix D: Output form the objective evaluation

The following is an example of the statistical output from a collocation between ice analysis and OSISAF ice products.

Reading IA
Ice concentration comparison
Importing SAF CT field
Performing analysis

IA	NP	<-20%	>-20%	>-10%	Exact	<+10%	<+20%	>+20%	Bias	Std.dev
0 - 0	29231	0	0	0	92	7	1	0	0.40	2.23
40 - 60	125	20	5	8	18	27	22	0	-4.06	17.87
60 - 70	82	6	27	41	24	1	0	0	-6.92	7.04
60 - 80	1861	56	11	10	22	1	0	0	-24.05	19.79
70 - 90	898	27	8	13	35	17	0	0	-12.54	20.56
80 - 90	68	0	0	0	0	99	1	0	8.24	1.25
90 - 90	2962	38	18	20	0	24	1	0	-14.90	17.68
90-100	9789	4	12	19	63	1	0	0	-3.84	7.24
100-100	228	0	33	66	0	0	0	0	-8.49	3.62
Total:	45244	6	5	6	75	7	1	0	-2.84	9.89
Ice only:	16013	18	13	18	43	7	0	0	-8.76	14.60

Ice edge comparison
Importing SAF CT field
Performing analysis
       Ice edge stats
     IA\SAF   Ice   Water

     Water,   120, 29144
      Ice, 15583,   588

Appendix E: Manual error registration

In the following we distinguish between error features and noise features:
- Errors features occur from day to day. They are unpredictable in time and space. In the long run errors should not be frequent. One should seek to eliminate errors in the short run.

- Features of noise occur frequently. Features of noise are to a certain extent predictable in time and space. Noise should be reduced or eliminated in the long run.

The error and noise features that are described in this section are features which are currently observed in the products from time to time. When processing changes due to changes in algorithms or processing methods the error and noise features are likely to change as well. As a consequence the procedures used for registering error and noise features will be adapted continually.

At present the following error types are searched for in the registration:

| Error/noise code	Type	Description
1	Area	missing data
2	Point	open water where ice was expected
3	Area	false ice where open water was expected
4	Point	false ice induced from SSM/I processing errors
5	Point	other errors
6	Point	noisy false ice along coast

Table 13: Error codes for the manual registration.

Error codes:

Code 1 – missing data)
Description: input data missing in all of the product or part of the product.
Recognized as: black patches in areas supposed to be covered by ice or water (see Figure 1 below)
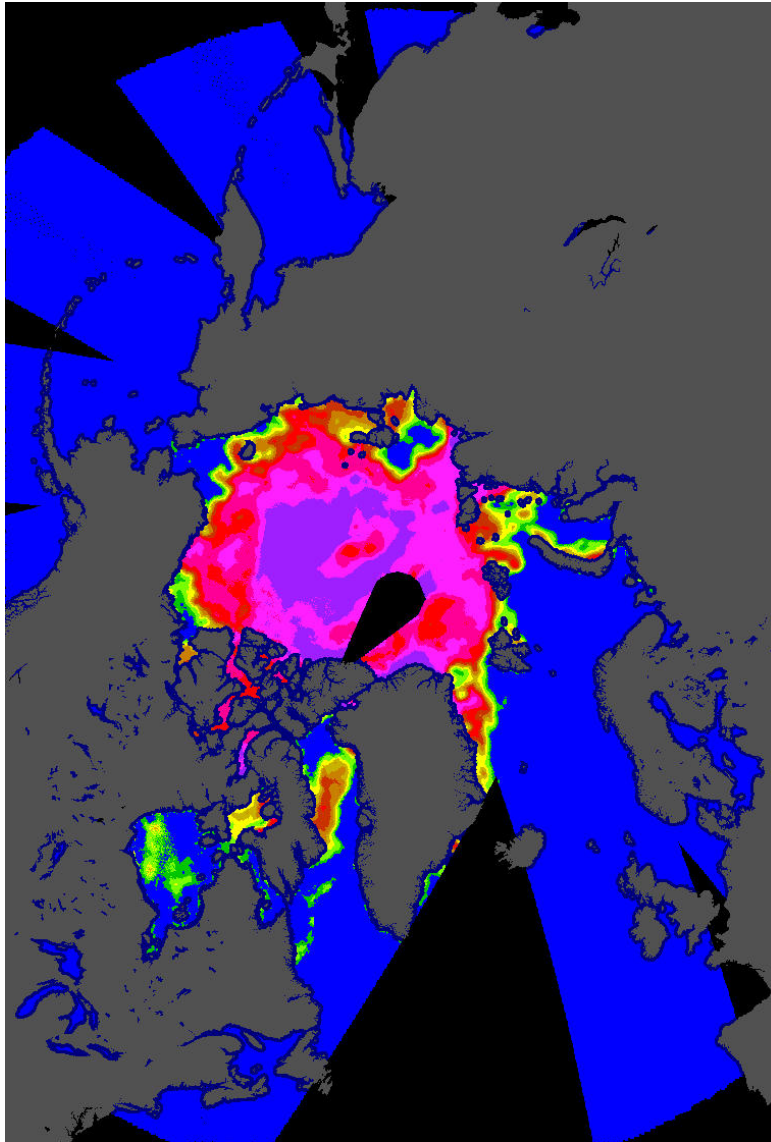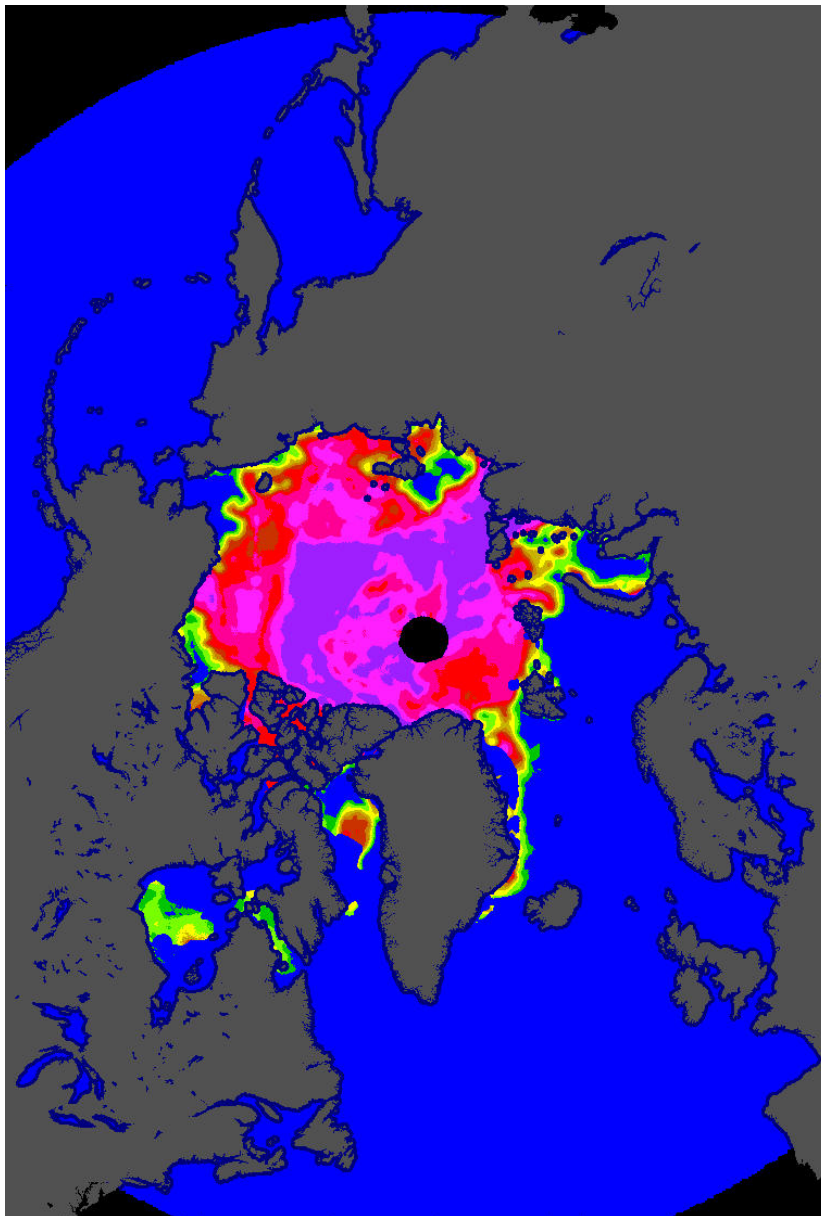
Figure 2: Error code 1: missing input satellite data.

Code 2 - open water where ice was expected

Description: areas of open water which are not expected when taking into consideration the time and location of the observed feature.

Recognized as: areas of open water which does not have a marked gradient towards ice with high concentrations. If present, this type of error is typically observed during summer. During processing of the ice products a filter is applied for removing sporadic occurrences of false ice considered as noise. The filter is based on the two meter air temperature from NWP models and the approach assumes no ice above a certain temperature threshold. However, during summer the ice can be underneath air masses that are close to the air temperature threshold chosen. In rare cases the filter 'cuts slices' into the ice (see Figure 2 below). As a consequence the threshold is adjusted according to season.

Figure 3: Error code 2: erroneous areas of open water caused by filtering using the 2m air temperature.

Code 3 –false ice where open water was expected
Description: areas covered by ice which are not expected when taking into consideration the time and location of the observed feature.
Recognized as: sporadic ice, irregular in shape, usually with low concentrations and usually temporary, i.e. ice that are not present at the same spot two days in a row (see Figure 3 below). Usually sporadic low concentration ice is removed by the temperature filter, however the temperature threshold is a trade-off between filtering of false ice and not filtering true ice (error code 2).
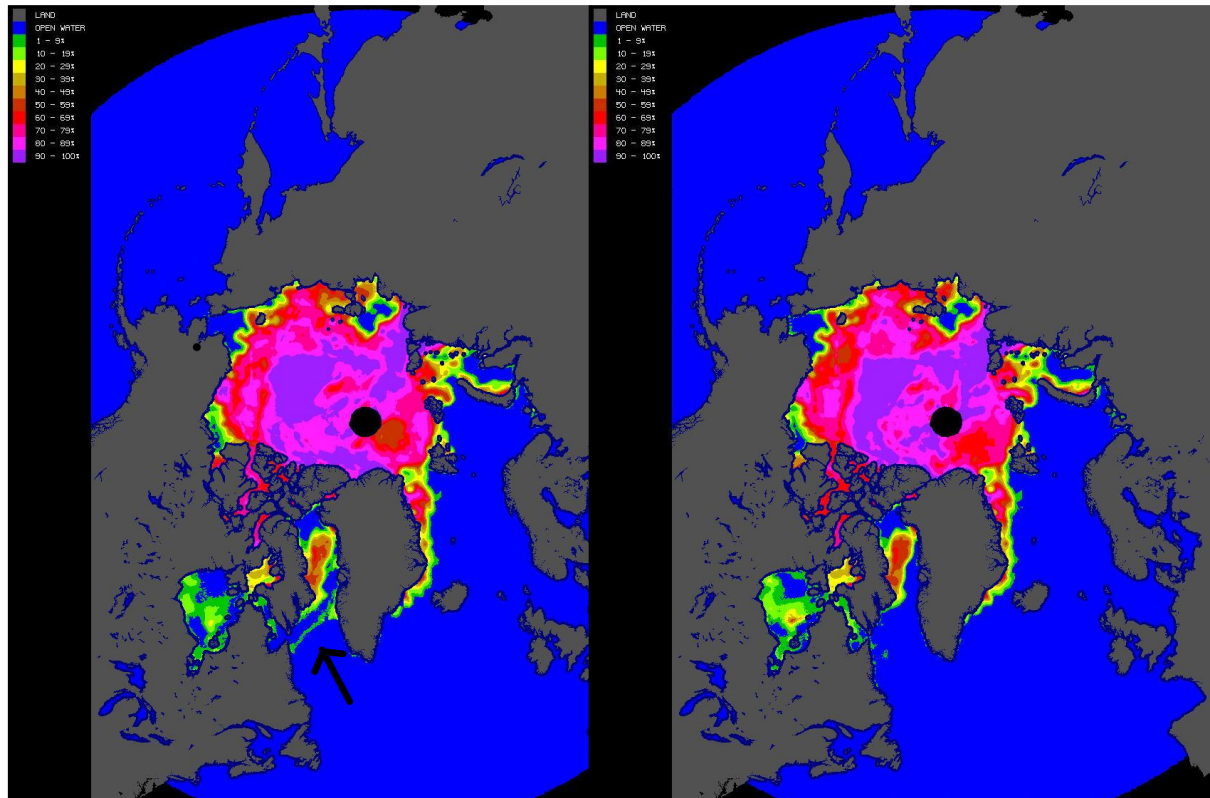

Figure 4: Error code 3: sporadic ice with low concentration (left). To the right is shown the situation the day before the left picture.

Code 4 - false ice induced from SSM/I processing errors
Description: Limited areas of ice with both low and high concentrations in a specific pattern coinciding with a subset of a scan line from the SSM/I instrument.
Recognized as: areas of ice with varying concentration in a pattern that looks like pearls on a string, possibly occurring both within the ice and in open water (see Figure 4 below). This error is caused by erroneous processing of the SSM/I data.
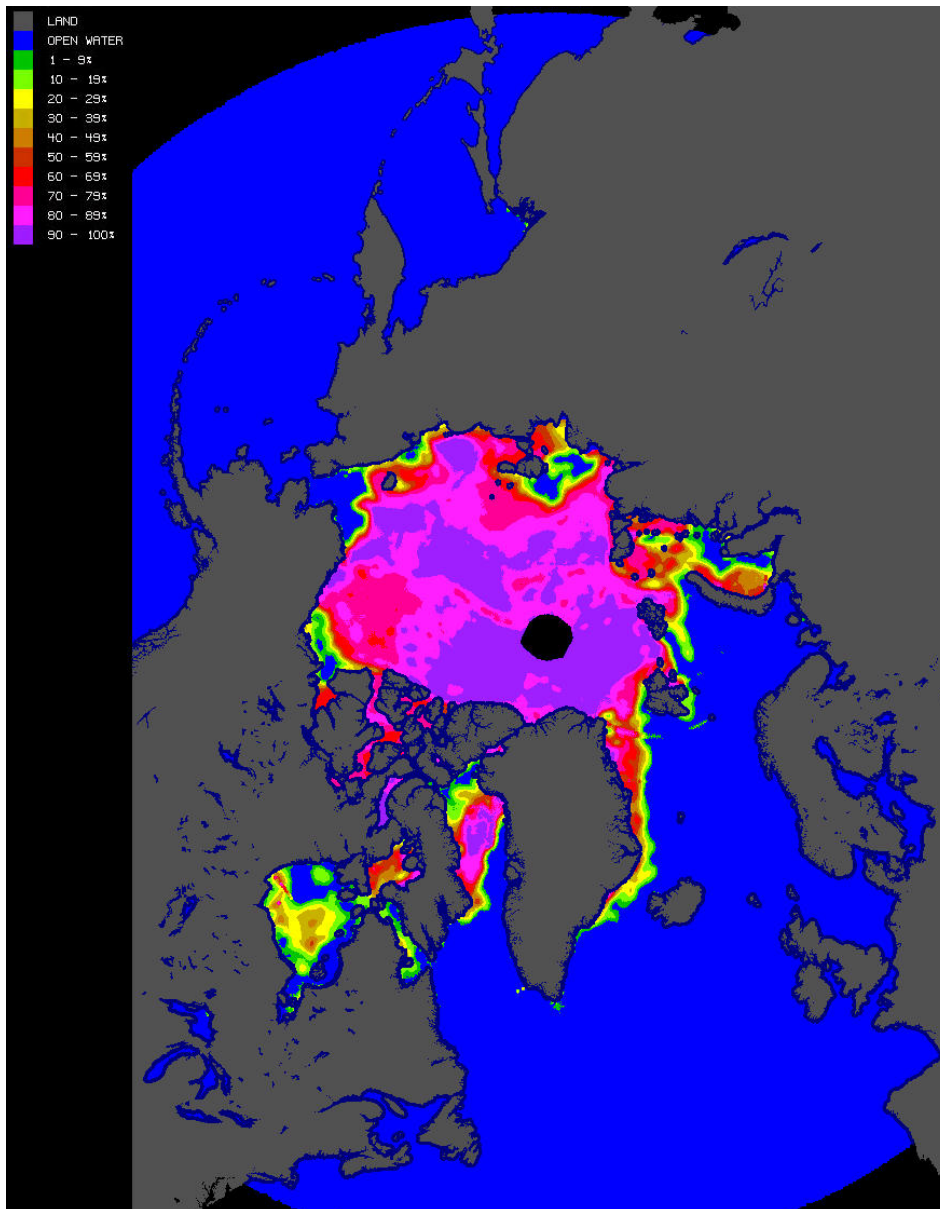

Figure 5: Error code 4: false ice or ice with erroneous concentrations caused by erroneous processing of the instrument data.

Code 5 – other errors
Description: This code is preserved for errors that are distinct from the other four types of errors.

Noise codes

Code 6 – noisy false ice along coast
Description: Noise in the form of ice along the coast in areas where ice is not expected.
Recognized as: Limited areas of ice along the coast, mostly of low concentration. The noisy features are caused by land contamination of the SSM/I instrument in the coastal zone.